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DESIGN OPTIMIZATION OF PROPELLER BLADE SUBJECTED TO DIFFERENT LOADING CONDITIONS

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ABSTRACT
A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air) is accelerated behind the blade. Propeller dynamics can be modeled by both Bernoulli's principle and Newton's third law. Aircraft propeller is sometimes colloquially known as an air screw propeller The present work is directed towards the study of composite aircraft propeller working and its terminology, simulation and flow simulation of composite aircraft propeller has been performed. To analyze the composite aircraft propeller in ANSYS software.Static and dynamic analysis is to determine the deformation, stress and strain of the composite aircraft propeller blade. Fatigue analysis to estimate the life of the component.
The optimizing the propeller blades varying the no of blades 2,3&5 blades and also optimizing the material E-glass Epoxy, Aluminum Alloy and Carbon Epoxy. 3D modeling done in CATIA parametricsoftware
.

Aircraft

An **aircraft** is a machine that is able to fly by gaining support from the air. It counters the force of gravity by using either static lift or by using the dynamic lift of an airfoil, or in a few cases the downward thrust from engines. Common examples of aircraft include airplanes, helicopters, airships (inclu ding blimps), gliders, parameters and hot air.

The human activity that surrounds aircraft is called aviation. The science of aviation, including designing and building aircraft, is called aeronautics. Crewed aircraft are flown by an onboard pilot, but unmanned aerial vehicles may be remotely controlled or self-controlled by onboard computers. Aircraft may be classified by different criteria, such as lift type, aircraft propulsion, usage and others.

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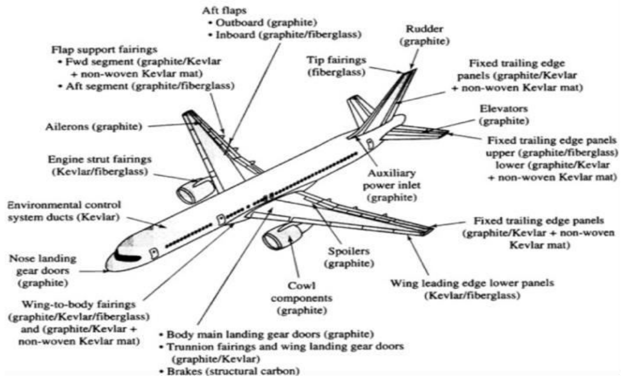
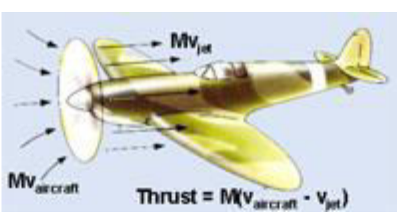


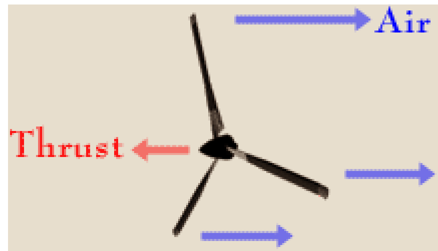
Figure 1.1 aircraft

Propeller blade

Thrust is the force that moves the aircraft through the air. Thrust is generated by the propulsion system of the aircraft. There are different types of propulsion systems develop thrust in different ways, although it usually generated through some application of Newton's Third Law. Propeller is one of the propulsion systems. The purpose of the propeller is to move the aircraft through the air. The propeller consists of two or more blades connected together by a hub. The hub serves to attach the blades to the engine shaft. .

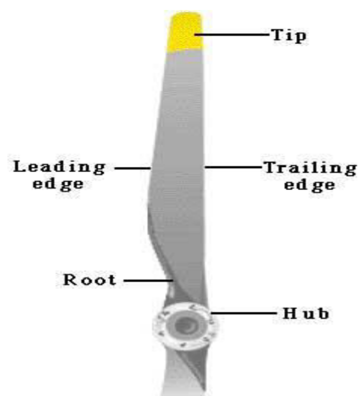


The blades are made in the shape of an airfoil like wing of an aircraft. When the engine rotates the propeller blades, the blades produce lift. This lift is called **thrust** and moves the aircraft forward. Most aircraft have propellers that pull the aircraft through the air. These are called **tractor** propellers. Some aircraft have propellers that **push** the aircraft. These are called **pusher** propellers.

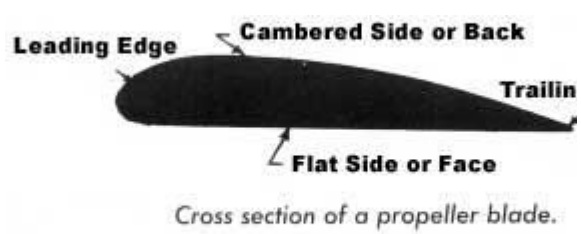


Description

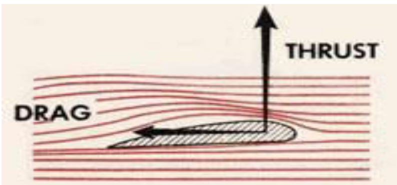
Leading Edge of the airfoil is the cutting edge that slices into the air. As the leading edge cuts the air, air flows over the blade face and the cambe side.



Blade Face is the surface of the propeller blade that corresponds to the lower surface of an airfoil or flat side, we called Blade Face.



Blade Back / Thrust Face is the curved surface of the airfoil.



Blade Shank (Root) is the section of the blade nearest the hub.

Blade Tip is the outer end of the blade farthest from the hub.

LITERATURE REVIEW

Y.S Rao and B.S.Reddy [1] shows composite propeller blades are safe in case of resonance phenomena in their harmonic analysis. Vibration defect can also be controlled in case of composite as damping effect is more. They had done a comparison of harmonic analysis using ansys software between aluminium metal and S2 Glass fabric/Epoxy. From their result maximum displacement in case of composite is 0.08192 which very less than aluminium propeller blade 0.1784.

M.A.Khan et al[2] observed inter laminar shear stress for composite material considering different no of layer and shows there is strong bonding between the layers. Eigan value analysis shows composite material has 80.5% more natural frequency than aluminium propeller. In their static analysis they had shown composite consist of separate layer.

V Ganesh et al. [3] had done static and modal analysis for aluminium propeller and composite (carbon reinforced plastics) propeller. From their analysis it shows blade deflection in case composite propeller is very less compare to aluminium. Besides that they also observed the stress strain variation for the strength analysis.

INTRODUCTION TO CAD

Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design and Drafting) is also used.

INTRODUCTION TO CATIA

CATIA is an acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

CATIA is a multi platform 3D software suite developed by Dassault Systèmes, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modelling tool that unites the 3D parametric features with 2D tools and also addresses every design-to-manufacturing process.

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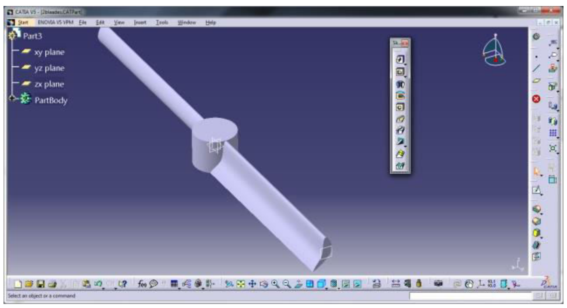
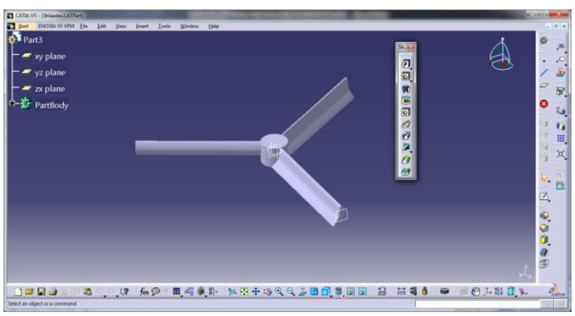
Design specifications

S.No	Parameters
1	2bladed propeller
2	Radius of hub = 50 mm
3	Radius of Propeller = 500mm
4	Power = 40kw
5	Rpm = 8000

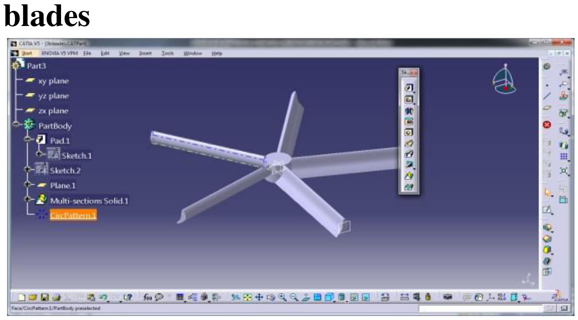
CASE1: aircraft propeller with 2 blades



CASE2: aircraft propeller with 3 blades



CASE3: aircraft propeller with 5 blades



INTRODUCTION TO FEA

Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering. For example, engineering strength of materials or the mathematical theory of elasticity can be used to calculate analytically the stresses and strains in a bent beam, but neither will be very successful in finding out what is happening in part of a car suspension system during cornering.

INTRODUCTION TO ANSYS

Structural Analysis

ANSYS Autodyn is computer simulation tool for simulating the response of materials to short duration severe loadings from impact, high pressure or explosions.

ANSYS Mechanical

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities

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STATIC ANALYSIS OF AIRCRAFT PROPELLER BLADE

Aluminum alloy

A	B	C	D
Property	Value	Unit	
Density	4620	kg m^-3	
Isotropic Secant Coefficient of Thermal Expansion			
Isotropic Elasticity			
Derive from	Young's Mod...		
Young's Modulus	9.6E+10	Pa	
Poisson's Ratio	0.36		

Carbon epoxy

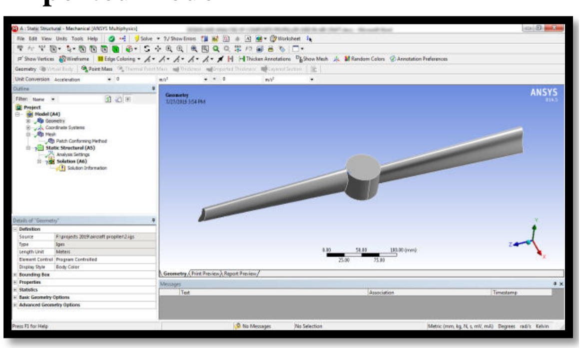
Property	Value	Unit
Density	1800	kg m^-3
Isotropic Elasticity		
Derive from	Young's Modu...	
Young's Modulus	4.5E+10	Pa
Poisson's Ratio	0.35	

E-glass epoxy

Property	Value	Unit
Density	2770	kg m^-3
Isotropic Elasticity		
Derive from	Young's Modu...	
Young's Modulus	7.1E+10	Pa
Poisson's Ratio	0.33	

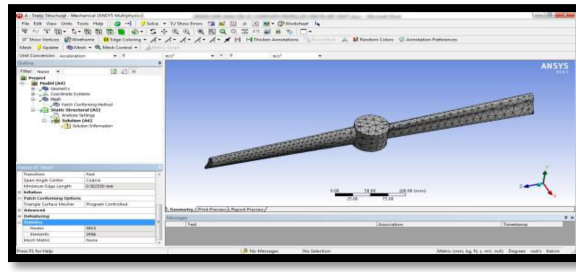
Case1: Aircraft propeller with 2 blades

Imported model



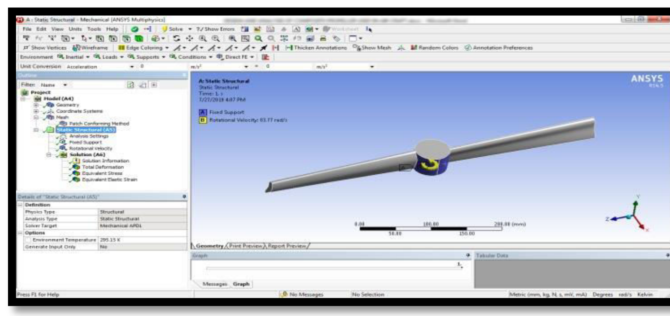
The above figure is imported in ANSYS which is developed in CREO software but this file should be in IGES format

Meshed model



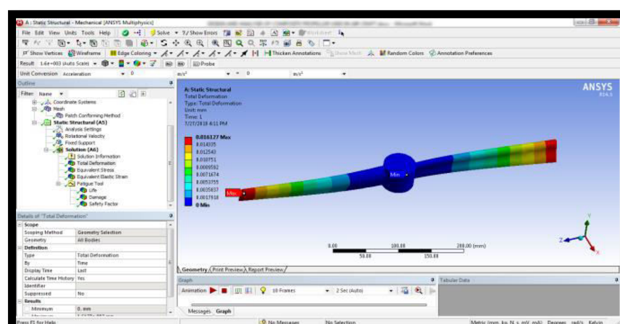
After importing the design 1 file , the meshing is completed for that which is using tetra hydro mesh > fine mesh for dividing the number of nodes and number of elements.

Boundary conditions



Material- carbon epoxy

Deformation



According to above figure the maximum deformation indicated in red color and minimum deformation indicated in blue color. The minimum deformation at starting of the propeller blade and hub, the maximum deformation at end of the propeller blade. The maximum deformation

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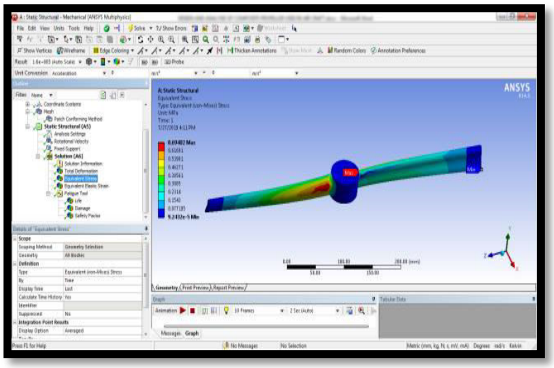
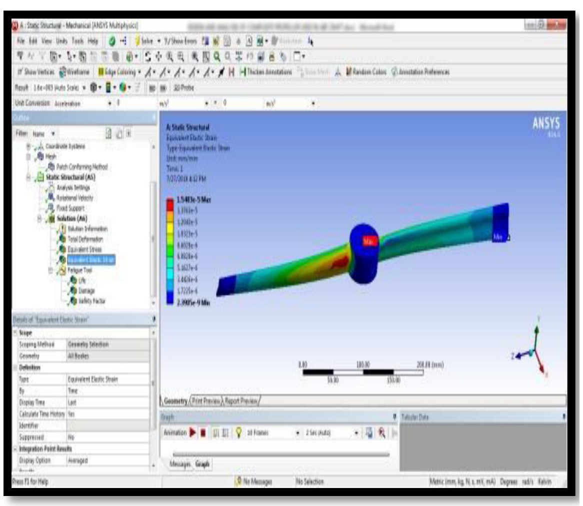
is 0.016277 mm and minimum deformation 0.00135mm.

Stress



According to above figure the maximum stress indicated in red color and minimum stress indicated in blue color. The minimum stress at starting of the propeller blade and hub, the maximum stress at end of the propeller blade. The maximum stress value 0.69402MPa, minimum stress value 0.071MPa.

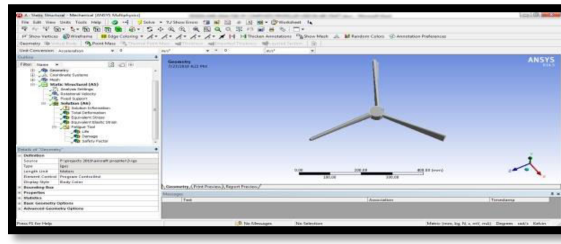
Strain



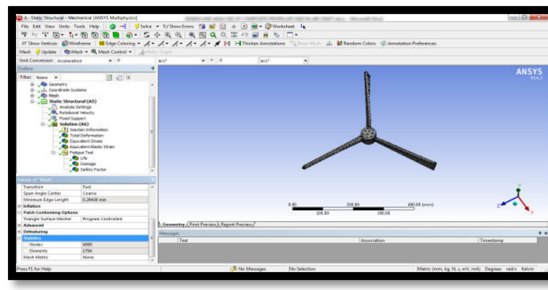
According to above figure the maximum strain indicated in red color and minimum strain indicated in blue color. The minimum strain at starting of the propeller blade and hub, the maximum strain at end of the propeller blade. The maximum strain value 1.543e-5, minimum strain value 1.7225e-6.

Case2: Aircraft propeller with 3 blades

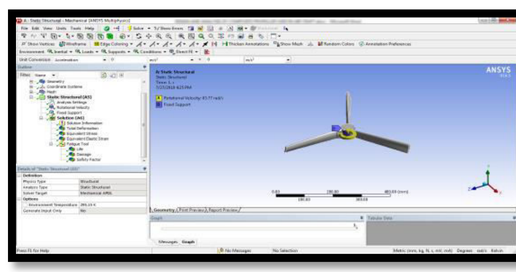
Imported model



Meshed model



Boundary conditions



Material- carbon epoxy

Deformation

According to above figure the maximum deformation indicated in red color and minimum deformation indicated in blue color. The minimum deformation at starting of the propeller blade and hub, the maximum deformation at end of the

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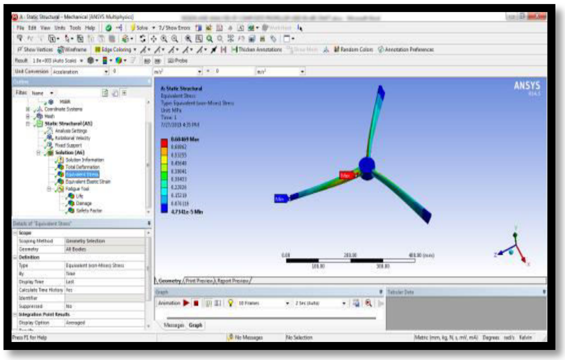
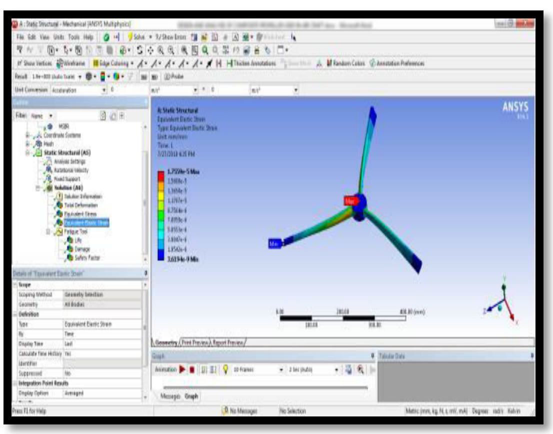
propeller blade. The maximum deformation is 0.015668 mm and minimum deformation 0.0013409mm.

Stress



According to above figure the maximum stress indicated in red color and minimum stress indicated in blue color. The minimum stress at starting of the propeller blade and hub, the maximum stress at end of the propeller blade. The maximum stress value 0.68469MPa, minimum stress value 0.07619MPa.

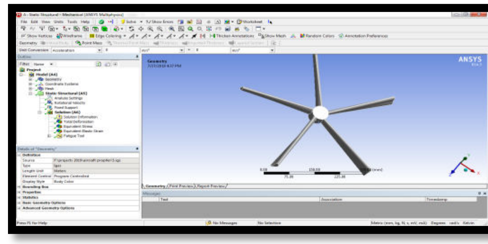
Strain



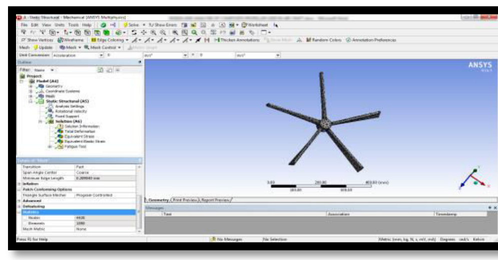
According to above figure the maximum strain indicated in red color and minimum strain indicated in blue color. The minimum strain at starting of the propeller blade and hub, the maximum strain at end of the propeller blade. The maximum strain value 1.7559e-5, minimum strain value 3.6194e-9.

Case3: Aircraft propeller with 5 blades

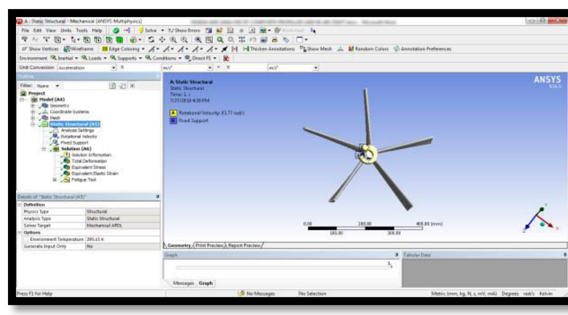
Imported model



Meshed model

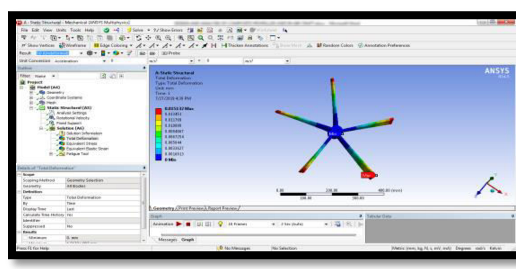


Boundary conditions



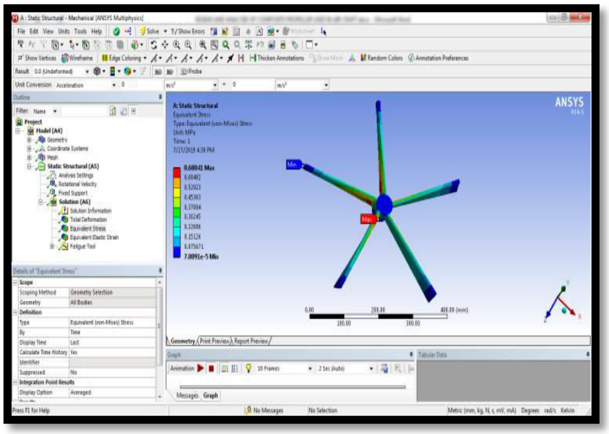
Material- carbon epoxy

Deformation



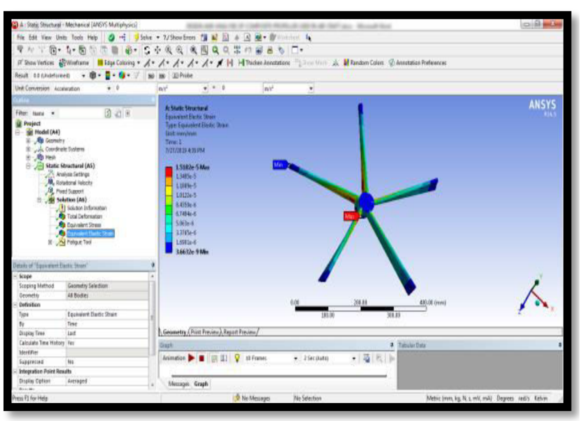
According to above figure the maximum deformation indicated in red color and minimum deformation indicated in blue color. The minimum deformation at starting of the propeller blade and hub, the maximum deformation at end of the propeller blade. The maximum deformation is 0.015832 mm and minimum deformation 0.0016827mm.

Stress



According to above figure the maximum stress indicated in red color and minimum stress indicated in blue color. The minimum stress at starting of the propeller blade and hub, the maximum stress at end of the propeller blade. The maximum stress value 0.68041MPa, minimum stress value 7.8095e-5MPa.

Strain



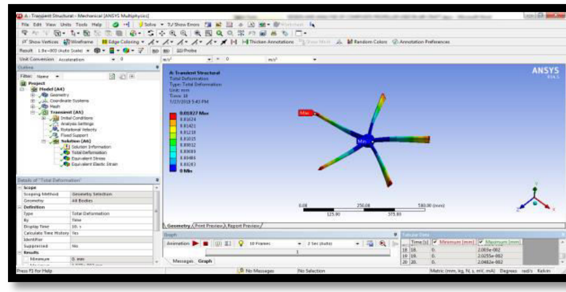
According to above figure the maximum strain indicated in red color and minimum strain indicated in blue color. The minimum strain at starting of the propeller blade and hub, the maximum strain at end of the propeller blade. The maximum strain value 1.5182e-5, minimum strain value 3.6632e-9.

aircraft propeller with 5 blades

Material- carbon epoxy

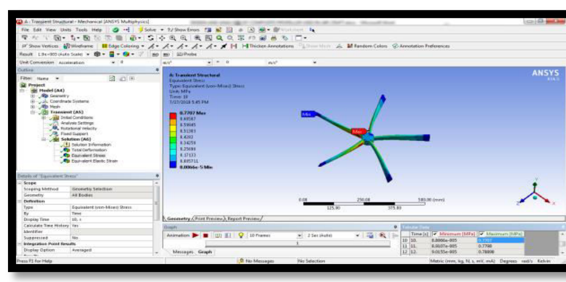
At time 10sec

Deformation



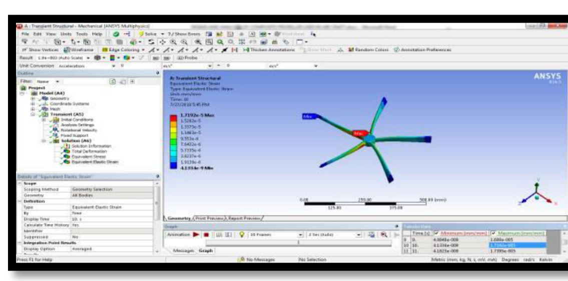
According to above figure the maximum deformation indicated in red color and minimum deformation indicated in blue color. The minimum deformation at starting of the propeller blade and hub, the maximum deformation at end of the propeller blade.

Stress



According to above figure the maximum stress indicated in red color and minimum stress indicated in blue color. The minimum stress at starting of the propeller blade and hub, the maximum stress at end of the propeller blade.

Strain



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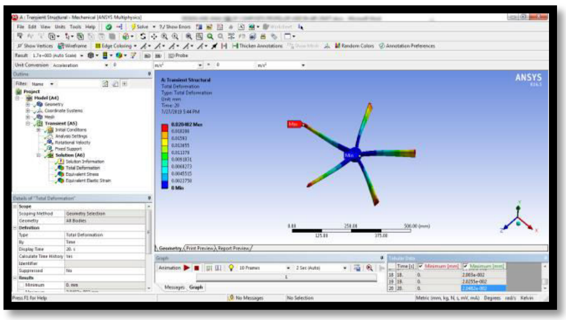
According to above figure the maximum strain indicated in red color and minimum strain indicated in blue color. The minimum strain at starting of the propeller blade and hub, the maximum strain at end of the propeller blade.

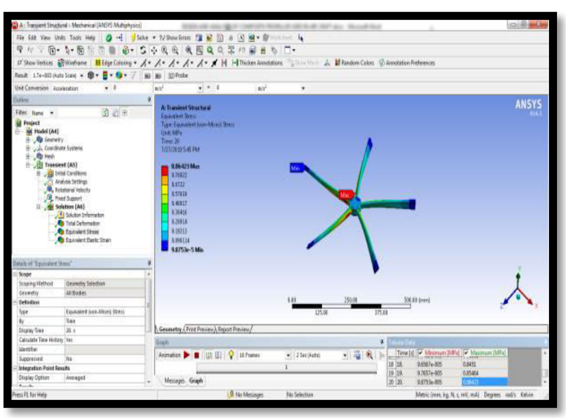
At time 20sec

Deformation



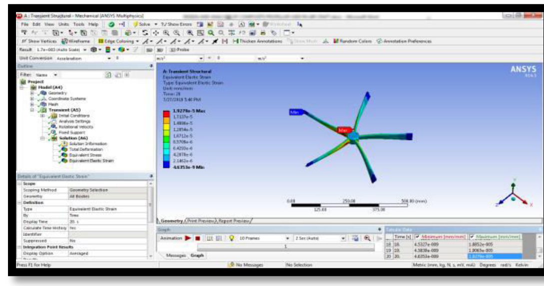
According to above figure the maximum deformation indicated in red color and minimum deformation indicated in blue color. The minimum deformation at starting of the propeller blade and hub, the maximum deformation at end of the propeller blade.

Stress



According to above figure the maximum stress indicated in red color and minimum stress indicated in blue color. The minimum stress at starting of the propeller blade and hub, the maximum stress at end of the propeller blade.

Strain



According to above figure the maximum strain indicated in red color and minimum strain indicated in blue color. The minimum strain at starting of the propeller blade and hub, the maximum strain at end of the propeller blade.

Static analysis results

Models	Materials	Deformation (mm)	Stress (MPa)	Strain	Safety factor
2 blades	Carbon epoxy	0.01627	0.69402	1.5483e-5	1.242
	e-glass epoxy	0.015777	1.0668	1.5082 e-5	0.80803
	Aluminum alloy	0.01937	1.7827	1.8645 e-5	0.48354
3 blades	Carbon epoxy	0.015668	0.68469	1.7559 e-5	1.259
	e-glass epoxy	0.015336	1.0533	1.6663 e-5	0.81836
	Aluminum alloy	0.018814	1.7577	2.1404 e-5	0.4904
5 blades	Carbon epoxy	0.015132	0.68041	1.518 e-5	1.2669
	E-glass epoxy	0.014832	1.0429	1.4744 e-5	0.82657
	Aluminum alloy	0.018156	1.7501	1.8307 e-5	0.49255

Dynamic analysis

Models	Materials	Time (sec)	Deformation (mm)	Stress (MPa)	Strain
2 blades	Carbon epoxy	10	0.021785	2.0105	2.1028e-5
		20	0.024417	2.2542	2.3576 e-5
	e-glass epoxy	10	0.017756	1.2033	1.7012 e-5
		20	0.019905	1.3494	1.9076 e-5
	Aluminum alloy	10	0.018148	0.7828	1.7464 e-5
		20	0.020345	0.87722	1.9884 e-5
3 blades	Carbon epoxy	10	0.017632	0.77215	1.9823 e-5
		20	0.019767	0.86585	2.2232 e-5
	e-glass epoxy	10	0.01726	1.879	1.8512 e-5
		20	0.019349	1.332	2.1097 e-5
	Aluminum alloy	10	0.02116	1.9819	2.4166 e-5
		20	0.02372	2.2224	2.7102 e-5
5 blades	Carbon epoxy	10	0.01827	0.7707	1.7192 e-5
		20	0.020482	0.86423	1.9279 e-5
	e-glass epoxy	10	0.017916	1.1837	1.6713 e-5
		20	0.020086	1.3273	1.8742 e-5
	Aluminum alloy	10	0.021905	1.982	2.0728 e-5
		20	0.024555	2.2225	2.3243 e-5

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CONCLUSION

The present work is directed towards the study of composite aircraft propeller working and its terminology, simulation and flow simulation of composite aircraft propeller has been performed. To analyze the composite aircraft propeller in ANSYS software.

Static and dynamic analysis is to determined the deformation, stress and strain of the composite aircraft propeller blade. Fatigue analysis to estimate the life of the component.

The optimized the propeller blades varying the no of blades 2,3&5 blades and also optimized the material E-glass Epoxy, Aluminum Alloy and Carbon Epoxy. 3D modeling done in CATIA parametric software.

By observing the static analysis results the less stress has 5 blades propeller compare with 2 blades and 3blades and comparison between materials the less stress has carbon epoxy material than e-glass epoxy and aluminum alloy.

By observing the fatigue analysis results the more safety factor has 5 blades propeller compare with 2 blades and 3blades and comparison between materials the less safety factor has carbon epoxy material than e-glass epoxy and aluminum alloy.

By observing the dynamic analysis results the less stress has 5 blades propeller compare with 2 blades and 3blades and comparison between materials the less stress has carbon epoxy material than e-glass epoxy and aluminum alloy.

So it can be concluded the aircraft propeller with 5 blades and carbon epoxy material is the better.

REFERENCES

[1] Das. H. N and Kapuria, S., “On the use of bend–twist coupling in full-scale composite marine propellers for improving hydrodynamic performance”, Journal of Fluids and Structures, Vol. 61, 2016, pp: 132–153.

[2] Rao, Y. S., and Reddy, B. S., “Harmonic Analysis of Composite Propeller for Marine Applications”, International Journal of Research & Technology (IJERT), Vol.1 Nov-2012 pp: 257-260

[3] Khan, M. A., Uddin, K. S.,and Ahmed, B., “Design and Dynamic Analysis on Composite Propeller of Ship Using FEA”, International Journal of Research & Technology(IJERT),Vol.2, January-2013, pp: 310-315

[4] Ganesh,V., Pradeep, K., and Srinvasulu, K., “Modelling and Analysis of Propeller Blade for its Strength” International Journal of Research & Technology(IJERT),Vol.3, February2014, pp: 291-300

[5] Yeo, K. B., Choong, W. H., and Hau, W. Y., “Prediction of Propeller Blade Stress Distribution Through FEA”, Journal of Applied Sciences,Vol.14,2014, pp.3046-3054.

[6] Barros,E. A. De., and Dantas, J.L.D., “Effect of Propeller Duct on AUV Maneuverability”, Ocean Engineering, Vol.42, 2012 pp:61-70

[7] Wei, Y. S., Wang, Y., Chang, S., and Fu, J., “Numerical Prediction of Propeller Excited Acoustic Response of Submarine Structure Based on CFD, FEM and BEM”, Journal of Hydrodynamics, Vol. 24 pp: 207-216

[8] Paik, B. G., Kim, G. D., Kim, K.Y., Seol, H.S., Hyun B. S.,Lee, S. G., Jung Y. R., "Investigation on the Performance Characteristics of the Flexible Propellers", Ocean Engineering, Vol.73, 2013, pp: 139–148

[9] Georgiades, C., Nahon, M., and Buehler, M., "Simulation of an Underwater Hexapod Robot", Ocean Engineering, Vol.36, 2009, pp: 39–47

[10] Barannyk, O.,Buckham, B. J., and Oshkai, P., "On Performance of an Oscillating Plate Underwater Propulsion System with Variable Chord wise Flexibility at Different Depths of Submergence", Journal of Fluids and Structures Vol. 28, 2012, pp: 152–166